THE EXPLOSIVES INCIDENTS DATABASE ADVISORY SERVICE (EIDAS)

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Introduction

Important lessons can be learnt from past mistakes. Careful analysis of the causes and effects of accidents can point to measures which can reduce both the chance and severity of further incidents. For this reason it is important that detailed information on accident circumstances, causes and effects be recorded and made widely available. Information on explosives accidents is likely to be of particular value to regulatory authorities, defence agencies, emergency services and safety consultancies as well as organisations which manufacture, process, store, transport or use explosives.

Before the advent of computerized databases, the recording and analyzing of accident data was often haphazard. Periodic weeding of paper records from files was not uncommon and this often resulted in the permanent loss of details of minor accidents, including those where a catastrophic outcome had been avoided because of fortuitous circumstances. However, the information contained in such records can provide valuable insights into the risks of an activity and any organization wishing to assess safety performance should systematically record and monitor such information. Whilst there has been a tendency for organizations to keep permanent records of major accidents, experience shows that these can prove difficult to retrieve: this information, in the form of official reports, articles in learned journals, conference proceedings etc, is often stored in diverse files and archives, and a painstaking search is thus sometimes necessary to uncover details about a specific accident or particular types of accidents.

There is thus a need for a service which collects information on explosives accidents, analyzes that information and stores it in a way such that it can be readily retrieved. This became particularly apparent in the UK in the late 1980s following completion of a number of risk assessment studies by both the UK Health and Safety Executive (HSE) and the Explosives Storage and Transport Committee of the UK Ministry of Defence (ESTC). An important component of these studies was the reconstruction of historical accident records; this was to allow inferences to be made about accident likelihood and outcome. This task would have been greatly facilitated had a single, comprehensive source of accident data been available.

Both the HSE and the MoD subsequently set up computerized databases to encode details of past and on-going accidents, both in the UK and worldwide, in order (i) to monitor the safety of activities involving explosives, (ii) to provide data for use in future risk assessment studies and (iii) to provide data that may be used to validate explosion effects models.

The HSE and the MoD subsequently merged their databases in 1991 and the Explosives Incidents Database Advisory Service (EIDAS) was thus inaugurated.

Aims of EIDAS

The principal aim of EIDAS is to provide an efficient management and control system capable of collecting, recording and distributing data on explosives incidents. The specific objectives within this principal aim are:

- to obtain as comprehensive a capture of data on explosives accidents as can be reasonably achieved;

- to encode pertinent details of these data on to an application developed from a desk-top Relational Database Management System (RDBMS);

- to provide the application with a user friendly interface that allows operators to retrieve records and generate tables, reports and statistics with the minimum of effort;

- to make the system widely available.

The service was set up by AEA Technology and is maintained by that organization on behalf of the HSE and MoD. Now that a working system is established, the HSE and MoD would like to extend data capture and open the system to international participation so that it can be of benefit to everyone and, in the process, improve further from the exchange of information.

Hardware Requirements

The EIDAS database has been developed using a commercial desk-top RDBMS (Microsoft Access™) and runs on an IBM compatible PC of the following minimum specification:

- 80486 33mhz DX CPU
- 8 Mb RAM (16 recommended)
- 10Mb free hard disc space
- VGA monitor
- Microsoft Mouse™ (or equivalent)
- Printer for which there is a Windows™ driver
- Microsoft Windows™ V3.1 or later
- MS-DOS™ V 5.0 or later

The database operates within a Microsoft Windows™ environment and communicates with no other software other than the host runtime version of Microsoft Access™.

Structure of the Database

The main form of the database is shown in Figure 1. It comprises 24 fields covering all pertinent factors, including:

- Date
- Place
- Type of location (manufacturing site, storage area, maritime port etc)
- Type of activity (manufacture, storage, transport etc)
- Type of event (explosion, fire, loss of explosives)
- Source of explosives
- Cause of the incident
- Number of casualties

The final field on the form, the Abstract Field, is a 255-character text field which provides a brief description of the incident. The form has been designed both to provide an "at-a-glance" summary of each incident and to allow rapid searches to be carried out on all search parameters that are likely to be of interest. Full descriptions of all the fields on this form are presented in Appendix 1.

Recent developments to the database allow for the storage of source documents. This source documentation, scanned in from official reports, newspaper articles etc, can be easily accessed by simply clicking a command button on screen.

Whilst the database is capable of storing graphics, including photographs, this capability has not been used so far because of the memory limitations of many personal computers currently in use. It is intended that this option will be explored when these older computers are phased out and replaced by more powerful systems.

Searches may be carried out on all fields, either singly or in combination. The logical operators "or" and "not" may be used with text fields while searches on numeric fields may be carried out with the comparison operators "equal to", "greater than", "less than" and "between".

Users can generate accident statistics and accident listings and bring up brief reports on particular accidents.

Figure 1

Record No: 438

Security Code: General Release

Date: 22 03 1989

Source of Information: HSE REPORT

Official Report Available? Yes

Place:-

Country: UK

County: Cambridgeshire

City: Peterborough

Type of Event: Explosion

Type of Location: Road

Type of Activity: Transport

Source of Explosives: NEC

Primary Cause:-

Type of Sub/Article Slurry

NEQ: 800 **Kg**

Organisational: Procedure in Error

Proximate: Jolted load

Stimulus: Impact/Friction (Unspecified)

Consequences:-

Number Killed: 1

Number Injured: 107

Explosion Effects Data? Yes

Legislative Details? No

Abstract: Van carrying Powergel, Magna Primers, Ammon Gellit, detonators and fuseheads exploded in an industrial estate. Unsafely packaged fuseheads ignited by impact/friction when van went over ramp. Fire broke out and load exploded 10mins later killing fireman.

Experience with EIDAS thus far

EIDAS has now been in operation for five years. During this time the main rôle of EIDAS has been:

- to provide a monitoring service to keep the MoD and HSE informed of the number and types of explosives accidents occurring worldwide;

- to provide a first port of call for officials seeking information on specific incidents;

- to allow trends to be discerned from the stored data.

This rôle has been steadily enhanced by periodic modifications to the database which have improved storage capability, provided a better format of printed output, and an ever more friendly interface; the latter now allows interrogators to carry out complex searches and generate statistics without having to write computer code.

The database currently holds records of more than 3000 explosives accidents worldwide, spanning a period of 300 years, covering incidents from 17th Century gunpowder explosions to the most recent incidents of explosions, fires and "near misses". Most of these records have been encoded from public domain sources of information, though unpublished official reports have been accessed wherever possible.

Experience has shown that information available from public domain sources is often lacking in important detail. For example, newspaper reports typically provide little more than the date of an accident and a rough estimate of the number of casualties involved. Detailed information on the causes and effects of accidents is often not reported or sometimes inaccurately reported. Whilst the information collected from such sources can be useful for establishing basic trends, it cannot be used for generating accurate statistics. Accurate statistics can only be obtained from record sets which are comprehensive and which have been encoded from detailed and reliable sources of information.

More recently an exercise has been carried out to encode what is thought to be a comprehensive set of records for UK explosives accidents from 1974, the year of formation of the HSE, to the present date. This exercise has drawn on information kept in HSE files, including the official reports of accidents prepared by HSE inspectors. The aim of this exercise has been two fold:

- to provide a set of records that are readily accessible
- to generate statistical information from those records.

A statistical analysis of the fatal explosives accidents that have occurred in the UK during the above mentioned period is presented in Appendix 2.

It is now intended to carry out a similar exercise with the open records from the MoD.

Future Plans for EIDAS

The authors believe that EIDAS provides an ideal forum for sharing and exchanging information on explosives accidents. The value of the service would be greatly increased through the active participation of all organizations concerned with the safety of explosives. Information taken from official sources, rather than public domain sources, would help to make EIDAS more useful to everyone.

The HSE and MoD would like to offer organizations the chance to participate in EIDAS, to share and exchange information through the system and get full benefit from it. Participants would be supplied with a read-only version of the master database together with an empty writable version; the latter would allow organizations to encode details of their own incidents against laid down criteria; these details could then be imported into the master database, making EIDAS an even more effective tool. All information entered onto the database would be subject to QA controls to ensure consistent standards of encoding. Further developments to the database would be guided by user experience.

The HSE and MoD are keen to see EIDAS develop and be of benefit to the global community. The additional cost of greater participation would be funded initially by the HSE.

Further details may be obtained by writing to the authors at the addresses listed at the front of the paper.

Appendix 1

Form of the Database.

The main form of the EIDAS database is shown in Figure 1. It Comprises 24 fields, each of which are described in turn below:

Field 1 Record No.

A counter field providing a unique record number for each incident.

Field 2 Security Code:

This field is used to specify whether the record contains classified information. There are currently four predefined choices for this field:

General Release:

This denotes that all the information on the record is in the public domain.

HSE/MoD Eyes Only:

This denotes that the record contains confidential information which is only to be released to personnel within HSE/MoD.

HSE Eyes Only:

This denotes that the record contains confidential information which is only to be released to HSE personnel. There are no such records on the database at the present time.

MoD Eyes Only:

This denotes that the record contains confidential information which is only to be released to MoD personnel. There are no such records on the database at present time.

These security codes basically reflect the confidentiality traditionally given to the information held by government departments. However, under the open government initiative in the UK, there is a drive to remove unnecessary restrictions to the access of information and consequently these records will be examined with a view to declassifying them on the database.

Field 3 Source of Information:

A 20 character text field identifying the primary source of information for an incident.

Field 4 Official report available?

A Yes/No choice field indicating whether an official report on the incident is available.

Field 5 Documents

A Yes/No choice field indicating whether the source documents from which the record has been encoded have also been stored on the database. These documents can be accessed by clicking a command button on the screen.

Field 6 Date:

The date is entered in the format DD/MM/YYYY. The day and/or the month portion of this field may be left blank if the exact date of the incident is unknown.

Field 7 Country: **Field 8 County/State/Province:** **Field 9 City/Town/Village:**

Each of the above fields are 20 character text fields for recording the location of the incident. Any of these fields may be left blank if the exact location of the incident is not known.

Field 10 Type of Event:

A choice field for which one of the following key words may be selected:-

Explosion:

This denotes an event involving either a detonation or deflagration of explosives material.

Fire:

This denotes an event in which explosives material burns slowly, moderately or rapidly but without exploding (ie without producing an appreciable blast wave).

Loss of Explosives:

This denotes an incident in which explosives material is lost so as to be unrecoverable (a container of explosives dropped overboard a ship into the ocean, for example).

No Ignition:

This denotes any untoward event involving explosives material which did not result in the initiation, ignition or loss of that material.

Field 11 Type of Location:

A choice field describing the type of location where the incident occurred. One of the following key words may be selected:-

Manufacturing Site:
: This refers to a site where explosives or ammunition are manufactured and includes internal storage areas.

Processing Site:
: This refers to a military facility where ammunition is broken down, assembled or otherwise processed but not manufactured.

Storage Area
: This refers to facilities whose primary purpose is the storage of ammunition or explosives; it excludes magazines within manufacturing sites.

Road
Rail Line
Rail Yard/Siding
Maritime Port
Civilian Airport
Military Airfield
Air
Sea
Underwater
Waterway
Mine
Quarry
Demolition/Construction Site
Offshore Site
Firing range/Burning Ground
Other User Site:
: This refers to any site where explosives may be intentionally initiated other than mines, quarries, demolition/construction sites, firing ranges/burning grounds and offshore sites

Laboratory
Place of Entertainment
Shop or Market Stall
Other Commercial Premises
Domestic Premises
Not Known

Field 12 Type of Activity:

A choice field defining the type of activity that was being undertaken at the time of the incident. One of the following key words may be selected:-

Manufacture
Processing
Storage
Transport
Loading/Handling

This denotes an incident which occurred during the manoeuvring or handling of explosives either manually or by means of a mechanical device.

End Use:

This refers to an accident that occurred as a result of an intentional initiation of explosives (eg a botched demolition).

Disposal
Testing
Uncovering UXO (UXO: Unexploded Ordnance)
Not Known

Field 13 Source of Explosives:

A text field identifying the organization which owned the explosives substance or article involved in the incident.

Field 14 Type of Substance/Article:

A 20 character text field defining the type of explosives involved in the incident. Generic names for explosives substances/articles are entered into this field, eg

Shell, Bombs, Torpedoes etc
Ammunition - where the type of munition is not known
Nitroglycerine, Dynamite, Slurry etc
High Explosives - where the type of substance is not known
Fireworks

Brand names of civil explosives and full titles of military munitions are entered into the keywords field.

Field 15 NEQ

A single precision number field for recording the net explosive quantity (NEQ) of explosives involved in the incident. NEQs are recorded in units of kilograms.

Field 16 Keywords

The purpose of this field is to store a set of key words to facilitate searches for both generic types of explosives/ammunition and individual natures. For example, the commercial product Powergel (a slurry explosive manufactured by ICI plc) is classified by the UN scheme as “Explosive, Blasting, Type E”, (UN No. 0241) and is assigned to Hazard Division 1.1 and Compatibility Group D. The keywords that would be entered into this field for an incident involving this product would be “Powergel” and, in the case of a transport incident or an incident involving the stored product packaged for transport, “Blasting Explosives Type E”, “HD 1.1D” and “0241”.

Field 17 Primary Cause (Organizational):

Operator Error:

This refers to incidents caused by unauthorized actions by operators or non-compliance with process instructions.

Procedure in Error:

This refers to incidents caused by inherently unsafe procedures carried out as a result of a failure of safety management.

Unforeseeable Accident:

This refers to any incidents whose cause was unforeseen and did not involve any breach of process instructions, standards or regulations.

Failure to Assess Risk:

This denotes a failure by management to carry out a suitable and sufficient assessment of the risks to heath and safety in order to identify appropriate control measures.

Lack of Information:

This denotes a failure by management to provide such information as is necessary to ensure health and safety.

Poor Training:

This denotes a failure by management to provide such training as is necessary to ensure health and safety.

Poor Instruction:

This denotes a failure by management to provide such instruction as is necessary to ensure health and safety.

Poor Supervision:

This denotes a failure by management to provide such supervision as is necessary to ensure health and safety

Illegal Activity

Not Known

Most of the above choices are not mutually exclusive and it follows that more than one choice may be entered into this field.

Field 18 Primary Cause (Proximate):

This is a text field which defines the immediate cause of the accident. Some of the more common proximate causes of accidents are listed below.

Mechanical Failure:

Denotes an incident caused by the mechanical failure of an item of processing equipment or failure of a mechanical device within an explosives article.

Electrical Failure:

Denotes an incident caused by electrical failure, eg short circuit or power failure.

Lightning
Flooding
Sabotage/Deliberate
Contamination:

Denotes an incident caused by contamination of equipment or surfaces with explosives.

Hot Work:

Denotes an incident caused by the undertaking of hot work, eg use of oxy-acetylene torch.

Dropped Explosives
Incorrect Work Tool
Incorrect Machine Setting
Not Known

Field 19 Primary Cause (Stimulus):

External Fire/Heat
Impact
Friction
Impact/Friction (Unspecified)

This denotes an ignition caused by either a combination of impact and frictional forces or mechanical forces of an unspecified nature

Auto Initiation
Overpressure/Fragments
Electrostatic Impingement
Electromagnetic Radiation
Chemical Reaction

This denotes an ignition caused by the mixing of explosives material with incompatible substances.

Runaway Reaction

This denotes an ignition caused by a runaway chemical reaction during the manufacture of explosives (as may occur, for example, with too high a concentration of reactants in a nitrator vessel)

Not Applicable
Not Known

Field 20 Fatalities:

An integer number field to record the number of people killed in an incident.

Field 21 No. Injured:

An integer number field to record the number of people injured in an incident.

Field 22 Legislative details?

A Yes/No choice field indicating whether the incident occurred as a result of a breach of regulations, and, if so, whether details of the action taken by the regulatory authority are available. Details of such actions can be accessed by clicking a command button on the screen.

Field 23 Model validation data?

A Yes/No choice field indicating whether detailed information on crater dimensions, property damage etc is available; this information may be useful for validating explosion effects models. When available, this information can be accessed by clicking a command button on the screen.

Field 24 Abstract:

A 255 character text field providing a brief description of an incident. The field may also be searched for key words and phrases.

Appendix 2

Statistical Analysis of Fatal Explosives Accidents in the UK 1975 - 1993

The EIDAS Database has been interrogated to obtain statistics for fatal explosives accidents that occurred in the UK and were reported to the HSE in the years 1975 to 1993.

Table 1 provides an overview of the fatal accident record for these years.

Table 1: Annual Statistics for Fatal Explosives Accidents in the UK (1975 - 1993)

Year	Number of Fatal Accidents	Total Number of Fatalities
1975	1	1
1976	6	6
1977	2	2
1978	3	3
1979	4	5
1980	2	3
1981	0	0
1982	1	1
1983	2	2
1984	1	1
1985	0	0
1986	1	2
1987	2	2
1988	5	6
1989	2	4
1990	1	1
1991	2	2
1992	1	1
1993	2	2

A total of 38 fatal accidents were reported during this time and a total of 44 fatalities were recorded.

Table 2 lists these accidents in date order and identifies the type of location, type of activity, type of explosives and number of fatalities involved.

Table 2: List of Fatal Explosives Accidents Reported to the HSE in the Years 1975 - 1993

Day	Month	Year	Type of Location	Type of Activity	Type of Explosives	Fatalities
28	04	1975	Manufacturing Site	Manufacture	Lead azide	1
08	05	1976	Demolition/Construction Site	End Use	Gelatine 80%strength	1
13	05	1976	Manufacturing Site	Manufacture	PETN	1
30	07	1976	Demolition/Construction Site	End Use	Gleamex	1
28	09	1976	Domestic Premises	Loading/handling	Mine fuse	1
18	10	1976	Manufacturing Site	Uncovering UXO	PETN	1
06	12	1976	Manufacturing Site	Manufacture	7.62mm Cartridge	1
28	04	1977	Unspecified User Site	End Use	Black Powder	1
05	11	1977	Place of Entertainment	End Use	Fireworks	1
26	02	1978	Domestic Premises	Manufacture	Sodium chlorate/sugar	1
26	04	1978	Manufacturing Site	Manufacture	Pyrotechnic	1
30	04	1978	Manufacturing Site	Not Known	Detonator	1
		1979	Manufacturing Site	Uncovering UXO	Nitrocellulose	1
20	05	1979	Manufacturing Site	Disposal	Lead Styphnate	1
23	07	1979	Manufacturing Site	Manufacture	Detonator	1
14	10	1979	Unspecified User Site	End Use	Nitram & TNT	2
04	03	1980	Manufacturing Site	Disposal	Propellant	2
16	12	1980	Manufacturing Site	Manufacture	Pyrotechnic	1
23	03	1982	Manufacturing Site	Manufacture	Pyrotechnic	1
15	02	1983	Manufacturing Site	Manufacture	Fireworks	1
15	08	1983	Domestic Premises	Manufacture	Silver fulminate	1
31	12	1984	Domestic Premises	Manufacture	Sodium chlorate/sugar	1
20	02	1986	Manufacturing Site	Manufacture	Pyrotechnic	2
19	02	1987	Manufacturing Site	Manufacture	Pyrotechnic	1
05	08	1987	Unspecified User Site	Loading/handling	Colt.455 Ely Pistol	1
26	02	1988	Manufacturing Site	Cleaning	Pyrotechnic	1
09	03	1988	Manufacturing Site	Manufacture	Fireworks	1
14	06	1988	Manufacturing Site	Manufacture	Nitroglycerine	2
25	09	1988	Domestic Premises	Storage	Percussion caps	1
04	10	1988	Unspecified User Site	Loading/handling	Sodium chlorate/sugar	1
22	03	1989	Road	Transport	Slurry	1
17	07	1989	Storage Area	Disposal	Ammunition	3
06	09	1990	Manufacturing Site	Manufacture	Fireworks	1
01	09	1991	Other User Site	Loading/handling	Flare	1
13	09	1991	Other Commercial Premises	Loading/handling	Ammunition	1
29	07	1992	Manufacturing Site	Manufacture	Nitroglycerine	1
12	09	1993	Demolition/Construction Site	Disposal	Blasting explosives	1
21	12	1993	Quarry	Disposal	Shaped Charges	1

Table 3 lists the number of fatal explosives accidents that have occurred in different types of location.

Table 3: Breakdown of Fatal Explosives Accidents Reported to the HSE 1975 - 1993: by Type of Location

Type of Location	Number of Fatal Accidents	Number of Fatalities
Licensed Manufacturing Site	20	23
Domestic Premises	6	6
Other User Sites	5	6
Demolition/Construction Site	3	3
Licensed Storage Area	1	3
Quarry	1	1
Commercial Premises	1	1
Place of Entertainment	1	1

Six accidents were reported as having occurred in domestic premises. Three of these accidents involved homemade explosives, two involved munitions which had either been found or stolen, and the other incident involved illegally stored percussion caps.

Five accidents were reported as having occurred in "other user sites", ie locations where explosives were intentionally initiated other than at mines, quarries, firing ranges, burning grounds, demolition/construction sites, underwater and offshore sites. One incident involved the explosion of a homemade gun, another the explosion of an Ely pistol, another the initiation of a homemade missile in a timber yard, another involved the initiation of a distress flare on a water front; and the fifth incident occurred in an underground cave. In this latter incident, a group of potholers used a mixture of nitram and TNT to blast a passage through to further caves; two of the potholers returned to the cave too soon after the blast and were overcome by toxic fumes.

The one incident reported in a licensed storage area was similar to that just described. In this case three soldiers died when inspecting a disposal site within the storage depot; munitions had been detonated in an unventilated area and the soldiers succumbed to carbon monoxide poisoning during the subsequent inspection.

Three fatal accident were reported during demolition/construction work. Two of these incidents were caused by the premature initiation of electric detonators: in one case a detonator in a box came into contact with a battery, and in the other case an error was made during the process of connecting electrical leads to the detonator. In the third incident a spectator in a crowd gathered to watch the demolition of two large tower blocks was hit by a fragment.

A fatal accident occurred in a disused quarry during the disposal by burning of shaped charges. In this case it is believed that the person carrying out the disposal miscounted the number of explosions and approached the fire too soon; he was hit in the abdomen by a fragment.

The accident which occurred at the commercial premises was in fact a transportation accident. A van carrying a mixture of high explosives drove over a speed ramp in an industrial estate, causing

the load to receive a jolt. The jolt was sufficient to initiate unsafely packaged fuseheads within the load, this in turn started a fire which initiated the high explosives about 10 minutes later. The final accident not involving manufacture occurred during a fireworks display. Up to three factors may have contributed towards this accident: there was a possibility that the fireworks were faulty due to bad manufacture; the mortar tubes used for launching the fireworks were not dug into the ground to the correct depth; and the operator approached the mortar tube from the wrong direction.

It is seen that most accidents occurred in licensed manufacturing sites. A further breakdown of these accidents by type of explosives and cause of initiation is shown in Table 4.

Table 4: Accidents in Licensed Manufacturing Sites Reported to the HSE 1975 - 1993

Type of Activity	Type of Explosives	Cause: Proximate	Cause: Stimulus
Manufacture	Lead azide	Contamination	Impact/friction
Manufacture	PETN	Incorrect Work Tool	Impact/friction
Uncovering UXO	PETN	Hot Work; Contamination	External Fire/heat
Manufacture	Small arms ammo	Mechanical Failure	Impact/friction
Manufacture	Pyrotechnic	Contamination	Impact/friction
Not Known	Detonator	Suicide	Not Known
Uncovering UXO	Nitrocellulose	Hot Work; Contamination	Impact/friction
Disposal	Lead styphnate	Contamination	Impact/friction
Not Known	Detonator	Suicide	Impact/friction
Manufacture	Propellant	Dropped Explosives	Impact/friction
Manufacture	Pyrotechnic	Mechanical Failure	Impact/friction
Manufacture	Pyrotechnic	Contamination	Impact/friction
Manufacture	Fireworks	Contamination	Not Known
Manufacture	Pyrotechnic	Poor Segregation	Electrostatic
Manufacture	Pyrotechnic	Not Known	Impact/friction
Manufacture	Pyrotechnic	Incompatibility	Chemical
Manufacture	Fireworks	Incorrect Work Tool	Reaction
Manufacture	Nitroglycerine	Not Known	Impact/friction
Manufacture	Fireworks	Incorrect Machine Setting	Impact/friction
Manufacture	Nitroglycerine	Contamination	Impact/friction
			Impact/friction

It is seen that most of these accidents involved sensitive types of explosives: two involved primary explosives (lead azide and lead styphnate); two involved nitroglycerine, one involved nitrocellulose and nine involved pyrotechnic compositions or fireworks. Two accidents involved PETN, a relatively sensitive secondary explosive (F of I = 50). There have been no reported fatalities caused by ignitions of insensitive explosives compounds or compositions (ie those with an F of I > 90).

The immediate cause of eight of these accidents can be ascribed to contamination: a workman was killed during maintenance work on machinery which had not first been properly decontaminated of lead azide; an operator was killed when he removed a component from a machine contaminated with dusty pyrotechnic composition; an operator was killed during the opening of a dryer door contaminated with previously spilt pyrotechnic composition; an operator was killed as a result of

an impact/friction-induced initiation of nitroglycerine condensed on process equipment; another operator was killed as a result of a friction-induced initiation of pyrotechnic composition during fireworks manufacture; two accidents were caused by hot work on equipment which had not been properly decontaminated; the final accident occurred when a workman simply picked up a section of pipe that had been contaminated with lead styphnate.

Two accidents were caused by the use of incorrect tools: in one case a workman used a steel tool to remove PETN scale from processing equipment, in the other case a spark from a steel tool ignited pyrotechnic composition during fireworks manufacture.

Two accidents were caused by mechanical failure: in one case a machine malfunction resulted in two cartridges being fed into profiling gauge position; in the other case metal to metal contact between blades and an end plate of a mixing machine resulted in an ignition of pyrotechnic composition.

Two workers were killed in an accident involving a fall of explosives: in this case a truck carrying wetted waste propellant toppled over causing an explosion.

Two workers were killed as a result of a static discharge igniting a pyrotechnic composition: in this case there was inadequate segregation of the workers from the pyrotechnic.

The two incidents involving detonators were both suicides.